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A PERSONNEL READINESS TRAINING PROGRAM: OPERATION OF THE AN/BQR-20A

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Performance-oriented tests were used to diagnose deficiencies in job performance among Fleet personnel. Self-instructional training materials, designed for shipboard use, were then individually prescribed to correct identified deficiencies. Testing and training programs were developed for three applications: (1) the submarine Sonar Technician operating the AN/BQR-20A, (2) the submarine Missile Technician maintaining the Missile Test and Readiness Equipment, and (3) the Boiler Technician operating and →

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maintaining the 1200 PSI Steam Propulsion Plant. This report describes the AN/BQR-20A application in which Sonar Technician Teams from 12 FBM submarines were given a diagnostic pretest and then retested approximately 5 months later. STs from four submarines were assigned to each of three experimental groups: (1) a Control Group in which the participants were given feedback on the pretest in terms of an overall percentage score, (2) a Feedback Group in which the members were given both an overall percentage score and a written outline indicating their specific weaknesses, and (3) a Feedback + Training Group in which the members were given the same type of information as the Feedback Group but were assigned specific remedial training. Diagnostic testing/shipboard remedial training appeared to be successful in both detecting and overcoming deficiencies of Fleet personnel. Feedback alone was not sufficient to bring about improvement in job performance.

END

FOREWORD

This Advanced Development effort was conducted in support of Project Z0108-PN (ZPN07), Education and Training Development, under the sponsorship of the Chief of Naval Operations (OP-099). This is the second in a series of reports relating to Subproject Z0108-PN.24, Personnel Readiness Training. The first report, NPRDC Special Report 75-8, A Personnel Readiness Training Program: Initial Project Developments, provided an overview of the project. Subsequent reports will describe the Personnel Readiness Training Programs for Missile Technicians and Boiler Technicians. A final report will summarize findings and conclusions across all three applications.

Appreciation is expressed to the following Commands and their staffs:

- Commander Submarine Force, U. S. Pacific Fleet and Commander Submarine Force, U. S. Atlantic Fleet for their cooperation and support in carrying out this project.

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- Commanding Officer, Naval Intelligence Support Center; Commander Submarine Development Group TWO, New London; and Commander Submarine School (SSEP), New London for a thorough review of the task analysis.

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J. J. CLARKIN
Commanding Officer

SUMMARY

Problem

The Personnel Readiness Training Program is concerned with the feasibility of utilizing a diagnostic testing/shipboard remedial training system to improve the readiness levels of Fleet personnel. In such a system, performance-oriented tests, which focus on the essential skills needed to do a job and refer to knowledges only as they are necessary to support those skills, are used to diagnose deficiencies in job performance. Self-instructional training materials which relate to essential aspects of the job are individually prescribed to correct deficiencies revealed by the diagnostic tests. To obtain information on how and where such a system might work, testing and training programs were developed for three applications: (1) the submarine Sonar Technician (ST) operating the AN/BQR-20A, (2) the submarine Missile Technician (MT) maintaining the Missile Test and Readiness Equipment (MTRE), and (3) the Boiler Technician (BT) operating and maintaining the 1200 PSI Steam Propulsion Plant.

Purpose

The purpose of the effort described in this report was to determine whether the testing and training programs developed for the ST application were instrumental in improving the performance of STs who operate the AN/BQR-20A.

Approach

Sonar Technician teams from 12 Fleet Ballistic Missile (FBM) submarines were given a diagnostic pretest and then retested approximately 5 months later. The test items concerned both the knowledge considered essential for proper operation of the AN/BQR-20A and the skills required to set up the front panel controls for various tactical situations. Three experimental groups, each consisting of ST teams from four submarines, were used in the evaluation: a Control Group, a Diagnostic Feedback Group, and a Diagnostic Feedback + Training Group. Following the pretest, members of the Control Group were given feedback on their test performance in terms of an overall percentage score. Members of the Feedback Group were given overall percentage scores, but, in addition, were provided with a written outline indicating their individual weaknesses. Members of the Diagnostic Feedback + Training Group were provided with the same type of information as the Feedback Group, but, additionally, were assigned specific remedial training materials covering their individual weaknesses.

Results

In general, on both the performance test and the equipment-related questions on the written test, the Training Group showed significant improvement from pre- to posttest while the Feedback and Control Groups showed little or no improvement.

Conclusions

1. For operation of the AN/BQR-20A, the diagnostic testing/shipboard training techniques which were developed are effective in both detecting and overcoming deficiencies.

2. In the ST application, feedback in the form of specific performance deficiencies was not in itself sufficient to bring about improvements in job performance.

3. Sonar Technicans in the FBM Fleet appear to have deficiencies in skills and knowledges related to the operation of the AN/BQR-20A.

Recommendation

In order to improve the proficiency level of Fleet operators, it is recommended that the AN/BQR-20A diagnostic testing/shipboard training program be implemented. Implementation should start with a shipboard training phase and diagnostic testing should begin at a later date.

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INTRODUCTION

Problem

The Personnel Readiness Training Program is concerned with the feasibility of utilizing a diagnostic testing/shipboard training system to improve the readiness levels of Fleet personnel.[1] In such a system, performance-oriented tests are used to diagnose deficiencies in job performance. Self-instructional training materials that relate to essential aspects of the job are then individually prescribed to correct deficiencies revealed by the diagnostic tests.

Background

The degree to which critical job skills can be improved through a system of diagnostic testing and shipboard training may depend on the rating and/or the type of task involved. Therefore, to obtain information on how and where the system might work, testing and training programs were developed for three applications. The ratings and related equipments selected for the program evaluation were: (1) the submarine Sonar Technician (ST) operating the AN/BQR-20A, (2) the submarine Missile Technician (MT) maintaining the Missile Test and Readiness Equipment (MTRE), and (3) the Boiler Technician (BT) operating and maintaining the 1200 PSI Steam Propulsion Plant. These ratings and equipments were chosen because they were critical to the missions of their ships and they contained a sufficient variety of operator and maintenance tasks to permit the results to be generalized to other areas. Additionally, there was evidence that performance deficiencies might be present in these areas.

Purpose

The purpose of this effort was to determine whether the testing and training programs developed for submarine Sonar Technicians (STs) were instrumental in improving their performance on the operation of the AN/BQR-20A.

The AN/BQR-20A, a passive sonar receiving set found on board all FBM submarines, is used for detection and analysis of sonar contacts. In fulfilling their mission, a prime requisite for FBM submarines is that they avoid being detected by a potential adversary. Because of its long-range detection capability, the AN/BQR-20A serves a vital role in the mission of these submarines. This specialized piece of sonar equipment requires only a single operator and has a relatively limited number of tasks involved in its operation. Thus, within acceptable time limits, it was possible to test all major operator tasks and most auxiliary tasks. Additionally, since the AN/BQR-20A is installed at most submarine shore facilities, testing could be accomplished ashore with the actual equipment during FBM submarine off-crew periods.

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[1]Laabs, G. J., Main, R. E., Abrams, A. J., & Steinemann, J. H. A personnel readiness training program: Initial project developments (NPRDC Special Report 75-8). San Diego: Navy Personnel Research and Development Center, April 1975.

METHOD

Description of Materials

AN/BQR-20A Operator Task Analysis

It is generally accepted that training and testing materials are most valid when they are derived from a task analysis. When this project began, no task analysis was available for the operation of the AN/BQR-20A. Therefore, initial efforts were devoted to developing a detailed task analysis. This was done by (1) breaking down the overall operator task into the specific tactical employments of the system (i.e., detection, contact investigation, tracking, and auxiliary uses), (2) outlining, for each tactical employment, a step-by-step procedure for properly setting the front panel and cathode ray tube (CRT) controls according to operational doctrine, and (3) providing, at each step in the procedure, an explanation as to why that particular control setting was recommended by doctrine. In this task analysis effort, operational doctrines of Commander Submarine Force, Atlantic (COMSUBLANT) and Commander Submarine Force, Pacific (COMSUBPAC) were used as authoritative sources. Since the doctrines were not explicit for contact investigation, procedures recommended by personnel from the Navy Intelligence Support Center (NISC) were incorporated into the task analysis. With this exception, the analysis is consistent with doctrine promulgated by COMSUBLANT and COMSUBPAC. The final version was reviewed in detail with experienced STs in the Fleet, and with personnel at NISC, at Submarine Development Group TWO, and at the Submarine School, New London.[2]

Diagnostic Test

The diagnostic test instruments, consisting of a hands-on performance test and a written test, were based upon the task analysis. For the performance test, the AN/BQR-20A was interfaced with an AN/UNQ-7 tape recorder, and tapes were used to provide signal input into the system. Four tapes were developed for this test; three contained simulated sonar signals, produced by using signal generators, and one contained active sonar transmissions. In most instances, simulated materials were used to ensure that an ST would see a clear presentation on the CRT if he had the equipment set up properly for a given problem. Prior to administration of the performance test, the ST was given a set of written instructions which provided necessary background information and outlined the tasks he was expected to perform. The test required each ST to set up the equipment and to perform the search task, the contact investigation task, and the tracking task on three separate tapes. On two of these tapes, he was also required to set up the equipment to perform a signal-to-noise ratio (SNR) calculation. On the fourth tape, he was required to set up the equipment for a ping interception. In summary, then, each ST was required to perform the following tasks: three search, three contact investigation, three tracking, two SNR calculations, and one ping interception.

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[2]This task analysis is a classified document. Copies are available to authorized personnel upon request to this Command. Requests should be addressed to the attention of Code 302.

In the performance test, the emphasis was on accuracy in selecting those front panel and CRT control settings which were recommended by operational doctrine for given tactical situations. Thus, all pertinent front panel and CRT controls had to be properly set for each problem. Those controls on which the various settings have little effect on system performance (e.g., slope control) were not considered in scoring. Also, for controls on which a particular setting may be partially a matter of personal preference (e.g., CRT brightness control), any selected setting was scored as correct if it fell within an acceptable range. In the case of the CRT brightness control, a given setting was scored as incorrect only if it was so bright or so dim that pertinent information might be lost or obscured on the CRT. A highly qualified rater observed the performance of each ST as he set up the equipment. When the rater was informed by the ST that he had completed a problem, the rater recorded the position of each pertinent switch on a scoring sheet specially designed so that the actual scoring could be done later. Scoring procedures are described below:

1. On the search task, 11 switches were scored on each of the three problems, resulting in a total of 33 observations per ST.

2. For the contact investigation task, the test instructions provided two hypothetical conditions for performing the task. In the first condition (applicable to the first two problems), the ST was told that the tactical situation was such that it provided ample time to make a thorough investigation of the contact. In the second condition (applicable to the third problem), the ST was told that the tactical situation provided only minimum time to investigate for additional contact information. This was done since somewhat different procedures are required in each of these tactical situations. On each of the first two problems, 11 switches were scored; on the third, 10 switches were scored, yielding a total of 32 observations per ST.

3. On the tracking task, 11 switches were scored on each of the three problems, resulting in a total of 33 observations per ST.

4. The ping interception task involved one problem in which the ST was required to set up the equipment to intercept a ping pulse of unknown frequency. For this task, seven switches were scored for a total of seven observations per ST.

5. For the SNR calculation task, the ST was required--in two problems--to set up the equipment to make a SNR calculation and then, from the CRT presentation, to report the approximate dB value of the ratio. Since the stress of the performance test was on correct set-up procedures, the ST was not required to apply correction factors to determine the exact dB values. Inasmuch as this measurement can be made at a variety of front panel control settings, only the mode switch and the dB value for the ratio were scored, yielding four observations per ST.

For each ST, there were 109 operational steps that were observed over a total of 12 problems.

When scoring the test, the switch positions recorded on the answer sheets were compared to predetermined standards. The standard established for the individual switches was the switch position recommended by operational doctrine for the given tactical situation. Since each switch setting was recorded by the rater during the test and the scoring sheets were later compared against predetermined standards, subjective judgments on the part of the rater were largely avoided, both during the observation of performance and in the scoring of the test. As a check on the amount of rater subjectivity that might still be present, the objectivity of the performance test was evaluated by using two trained observers during the pretesting of ST teams from three submarines and comparing their observations.

The 42-item written test focused upon specific knowledges considered to be essential for proper operation of the system. Thirty-one of these questions were related specifically to the operation of the AN/BQR-20A, and 11 were concerned with general sonar knowledges which bear on the proper utilization of this equipment. Questions in the latter category covered such areas as selection of appropriate passive sonar under given conditions and calculation of the figure-of-merit when the values for the terms of the equation were given. In general, the written test covered areas which were not covered in the performance test. Both the performance and written tests were tried out on ST teams from FBM submarines before data gathering began.

Remedial Shipboard Training Materials

The shipboard training materials consisted of six self-instructional units, five logic tress, two ¼-inch training tapes, and six drills. In general, the self-instructional units presented basic information on system operation and the recommended settings for, and the proper relationship between, the individual front panel and CRT controls for various tactical employments of the system. The logic trees provided the trainee with a systematic procedure for properly setting up the AN/BQR-20A for search, tracking, contact investigation, determination of SNR, and ping interception. The two ¼-inch training tapes, which contained simulated sonar signals, were used in conjunction with the six drills to provide hands-on training on the equipment. The tapes provided signal input to the AN/BQR-20A via a tape recorder, so that the trainee could observe a presentation on the CRT as he worked through the drills.

There was one drill for each of the tasks (e.g., search, track, contact investigation). The drill format provided a switch-by-switch procedure for setting up the front panel and CRT controls for that particular tactical employment of the system. For each switch, the proper setting was given and an explanation was provided as to why that particular setting was recommended for the given situation. In a separate column, the incorrect settings for each switch were shown and an explanation was given of the adverse effects each incorrect setting could have on system performance. This format for the drills enabled one trainee to act as an instructor while another set up the controls on the equipment for the given problem. With this method, immediate feedback on any error in setting a switch was given to the trainee along with an explanation as to why that incorrect setting was undesirable in terms of system performance.

Shipboard training materials were assigned on the basis of diagnostic test error patterns. For this purpose, performance test results were analyzed both in terms of: (1) the number of times an individual switch was set incorrectly across all tasks and (2) the number of control panel and CRT switches set incorrectly within each task. Errors on specific written test items and the number of times an individual switch was set improperly in the performance test were used as the basis for assigning the self-instructional units. The logic trees and the drills were assigned on the basis of the number of switches set incorrectly within each task. Members of the Training Group were asked to complete their assigned training materials at times convenient for them during their subsequent patrol. A master list of training material assigned to each individual ST was provided to the Leading Petty Officer (LPO) for purposes of monitoring training and maintaining a record as each ST completed the assigned materials. Just how and when the training was to be accomplished was left up to the discretion of the individual LPOs. The recommended progression in using the training materials was from self-instructional units, to logic trees, to drills.

Experimental Conditions

The experimental design shown in Table 1 was used to evaluate the ST application of the Personnel Readiness Training Program. As depicted in the design, three experimental groups, each consisting of ST teams from four submarines, were used in the evaluation: A Control Group, a Diagnostic Feedback Group, and a Diagnostic Feedback + Training Group. Members of all three groups were given the previously described diagnostic tests and then were retested approximately 5 months later using the same tests. Since the same tests were used for the posttest, no feedback concerning which specific written test items were missed or which specific control settings were improperly set was given during the pretest. What happened to the individuals in the interim depended upon the group to which they were assigned.

Table 1

Experimental Design Used in ST Application of the Personnel Readiness Training Program

Group	Experimental Conditions		
Control	Pretest with non-specific feedback	Patrol	Posttest
Diagnostic Feedback	Pretest with specific feedback on weaknesses	Patrol	Posttest
Diagnostic Feedback + Training	Pretest with specific feedback on weaknesses and remedial training assigned	Patrol AN/BQR-20A Training Package onboard	Posttest

Description of Groups

Control Group. Following the pretest, ST teams in this group were given feedback on their test performance in terms of an overall percentage score. For example, an ST participating in this group might be told that he answered 70 percent of the written test items correctly and set 62 percent of the controls in the recommended positions on the performance test. Members of this group were not provided with any information concerning their specific deficiencies and they were not given suggestions or directions as to how their deficiencies might be corrected.

Diagnostic Feedback Group. Following the pretest, members of this group were also given overall percentage scores but, in addition, they were provided with a written outline indicating their individual weaknesses. This outline pointed out specific weaknesses both in terms of (1) front panel and CRT controls which had frequently been used improperly and (2) tasks (e.g., search, track, contact investigation) which showed overall performance deficiencies. For example, in addition to his test percentage scores, an ST might be informed that he was weak on the use of the range control switch and the signal gain controls and that his performance was inadequate on the tasks of search and contact investigation. As with the Control Group, members of this group were not provided with any information as to how their deficiencies might be corrected.

Diagnostic Feedback + Training Group. Following the pretest, members in this group were given the same type of feedback as was given to those in the Diagnostic Feedback Group, i.e., percentage scores and specific weaknesses in terms of individual switches and tasks. In addition, they were assigned specific remedial training materials covering their individual weaknesses. For example, if the test results for an ST in this group indicated that his performance was deficient in the use of the range switch and in the use of signal gain control switches, he was assigned the self-instructional units which covered the use of the range switch and the proper settings for the gain control switches. Additionally, he was assigned logic trees and drills for each area in which his performance was deficient.

Sample

ST teams from 12 Fleet Ballistic Missile (FBM) submarines--six Atlantic Fleet (LANTFLT) and six Pacific Fleet (PACFLT)--participated in the program evaluation. The testing program was carried out in the FBM Fleet because: (1) the AN/BQR-20A is found onboard all FBM submarines, (2) the regularity of the FBM patrol cycle provided reasonable assurance that the time frame between pre- and posttesting would be relatively constant across crews, and (3) FBM crews could be tested at shore facilities during the off-crew period, thereby simplifying the problem of arranging for testing times and locations.

In LANTFLT, assignment of ST teams to the various groups was made by Commander, Submarine Group TWO for the three submarines tested in New London and Commander, Submarine Group SIX for the three submarines tested in Charleston. In PACFLT, however, the decision of group assignment was left up to the research team. Since pretesting was conducted initially in LANTFLT, assignment of ST teams in PACFLT was done on the basis of

the number of STs in a team in order to balance the number of participants in each experimental group. Of the 69 STs who were pretested, 22 were assigned to the Control Group, 23 to the Feedback Group, and 24 to the Feedback + Training Group.

A total of 56 STs were included in the final sample.[3] Length of Navy experience for STs varied from a minimum of 10 months to a maximum of 18 years, with the average being 4.8 years. The distribution of paygrades and the percentage of the total sample each represents are shown in Table 2.

Table 2

Percentage Distribution of Pay Grades in Experimental Groups

Pay Grades	Diagnostic Feedback + Training Group N=23	Diagnostic Feedback Group N=18	Control Group N=15	Total Sample N=56
E-2/E-3	13	6	7	9
E-4	40	61	66	53
E-5	17	22	13	18
E-6	17	11	7	13
E-7/E-8	13	0	7	7

<u>Procedures</u>

Fleet testing was conducted by members of the research team at FBM off-crew ports at New London, Charleston, and Pearl Harbor. The procedure followed in the testing program was to initially assemble an entire ST team in a classroom to take the written test. Before the pretest was administered, the STs were asked to complete a short biographical questionnaire and they

[3]Of the original 69 STs who took the pretest, 13 were unavailable for posttesting due to discharage from the Navy, transfer, or leave. Of the 56 STs included in the final sample, 8 had been assigned to various courses at Fleet Anti-Submarine Warfare Training Center, Pacific (FLEASWTRACENPAC), San Diego. Arrangements were made with FLEASWTRACENPAC to retest these students at the Center. None of them had received training on the AN/BQR-20A in their courses at the Center. Since statistical tests revealed no differences between this student group and those remaining in the submarine crews, the students were included in the final sample.

were briefed on the general purpose of the project and the procedures to be followed in the testing program. However, they were not told that there were three groups involved in the study. Depending upon the group to which they were assigned, each team was told the type of feedback information they would receive following testing. For example, members of the Training Group were told that they would be given their percentage scores on the tests, an outline pointing out their individual deficiencies, and an individualized prescription for remedial training. In this briefing, it was stressed to each team that they would be retested following their subsequent patrol. At the completion of the written test, a time schedule for each individual to take the hands-on performance test was arranged.

RESULTS AND DISCUSSION

In analyzing the data, a separate analysis of variance (ANOVA) was performed on each of the individual performance tasks and on each of the categories in the written test. The values resulting from these ANOVAs (F values) and levels of significance are reported in Table 3. When the overall ANOVA for a given task resulted in a significant interaction, additional analyses were performed on the data to determine simple main effects. The values resulting from these ANOVAs are presented in Table 4.

Performance Test

For search, contact investigation, tracking, and ping interception, the analyses were based upon the percentage of front panel and CRT control switches that were set in the proper position according to operational doctrine. In the case of SNR determination, however, both the switch setting and the answer given for the ratio were included in the scoring. At this point, three additional aspects of the scoring procedures should be pointed out:

1. The number of switches scored varied across tasks since only those switches that were relevant to performing a particular task were counted.

2. For those instances where a dependency relationship existed between two switches, the scoring procedure was to charge only one error if the switches were set at improper positions but in proper relationship to each other for the setting selected.

3. STs who made no attempt to perform a given task on the pretest, contrary to test instructions to do so, were not included in the analysis for that task, thus the group N's differ across tasks.

In discussing the performance test, the results on the primary and auxiliary uses of the AN/BQR-20A will be treated separately. The primary uses are search, contact investigation, and tracking, and auxiliary uses include ping interception and SNR calculation. Initially, the discussion will focus on the primary uses.

Table 3

F Values from Analysis of Variance for Five Performance Tasks and Two Categories of the Written Test

	Performance Test					Written Test	
Effect	Search (df = 53)	Contact Investigation (df = 53)	Tracking (df = 48)	Ping Interception (df = 44)	SNR (df = 53)	Equipment Related (df = 53)	General Sonar Knowledges (df = 53)
Group (df = 2)	16.27**	23.16**	3.12	.43	2.90	.52	.50
Pre-post (df = 1)	19.53**	25.56**	15.64**	.72	32.56**	15.41**	3.27
Group X Pre-Post Interaction (df = 2)	15.36**	26.25**	6.62*	2.40	1.92	3.19*	.11

**P < .01
*p < .05

Table 4

F Values for Tests of Simple Main Effects Between Pre- and Posttest when ANOVA Indicated a Significant Interaction

	Tasks						
	Performance Test					Written Test	
Effect	Search	Contact Investigation	Tracking	Ping Interception	SNR	Equipment Related	General Sonar Knowledges
Training	64.46**	99.38**	40.04**	Interaction not Significant	Interaction not Significant	20.92**	Interaction not Significant
Feedback	0	0	2.86			3.78	
Control	0	0	0			.33	

$^{**}p < .01$

Results on Primary Uses

There are differences in the percentage levels of both pre-and posttest performance on the search, contact investigation, and tracking tasks; however, as shown in Figures 1, 2, and 3, there is a high degree of consistency in how the individual treatment groups performed across these three tasks. On all three tasks, the Training Group showed significant improvement while the Feedback and Control Groups showed little or no improvement. For all three groups, the pretest performance on these tasks was uniformly low. Over all groups on the pretest, only about 75% of the front panel and CRT controls were set properly on the search task, 65% on the contact investigation task, and 67% on the tracking task. While it is accurate to say that, under some conditions, all of the available contact information may be obtained even when certain front panel controls are set improperly, the danger is that, on other occasions, these improper settings may make it unlikely that vital contact information will be obtained. Further, in other more serious cases, certain settings on some switches make it impossible to obtain contact information. Additionally, overdriving the signal, a condition observed frequently during testing, may create spurious, system-generated artifacts that can mask real contact information or be misinterpreted as relating to a nonexistent contact.

On the posttest, the Training Group improved significantly on all primary tasks. The group set 92 percent of the front panel and CRT controls correctly on the search task; 88 percent on the contact investigation task; and 80 percent on the tracking task. These figures represent an improvement in performance from pretest levels of 16 percent on search, 22 percent on contact investigation, and 11 percent on tracking. The fact that the greatest percentage improvement was shown on the contact investigation task is not surprising in view of the fact that existing operational doctrine on this equipment is not explicit on contact investigation procedures. As indicated previously, since there was no existing doctrine, the standard adopted for scoring this task in the testing program was based upon procedures recommended by job experts at NISC. These procedures were also incorporated into the training materials. Members of the Training Group were thus provided with training documentation in an area where none existed before. The lowest percentage of improvement was shown on the tracking task. On this task, there may have been less motivation to learn the proper procedures due to many of the STs' attitudes toward the task. On the pretest, and to a lesser degree on the posttest, many of the STs were somewhat resistive to performing this task. A frequent comment was that on the job they were never required to perform tracking, since active pursuit of a contact is not the primary mission of FBM submarines.

At this point, a question which may be asked is whether the level of performance attained by the Training Group on the posttest is adequate for these primary tasks. While this program did not deal specifically with the determination of criterion levels for performance, it is safe to say that the likelihood of detecting a contact and maintaining a track is considerably enhanced when a greater proportion of the switches on the control panel and CRT are set properly. In this regard, it should be pointed out that the improvement shown by the Training Group was achieved by spending only an average of 6.2 hours on self-instruction lessons, 2.8 hours on logic trees, and 1.8 hours on drills during one patrol. It seems reasonable to expect that having the training materials readily available for refresher training could result in additional improvement over time.

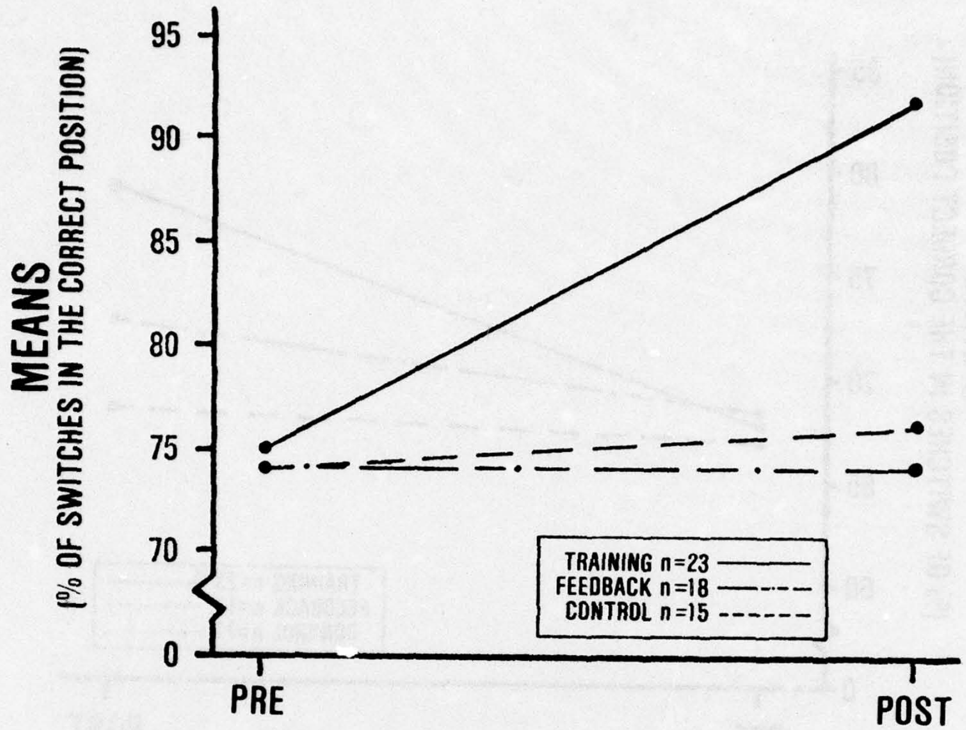

Figure 1. Pre- and Posttest Performance on the Search Task.

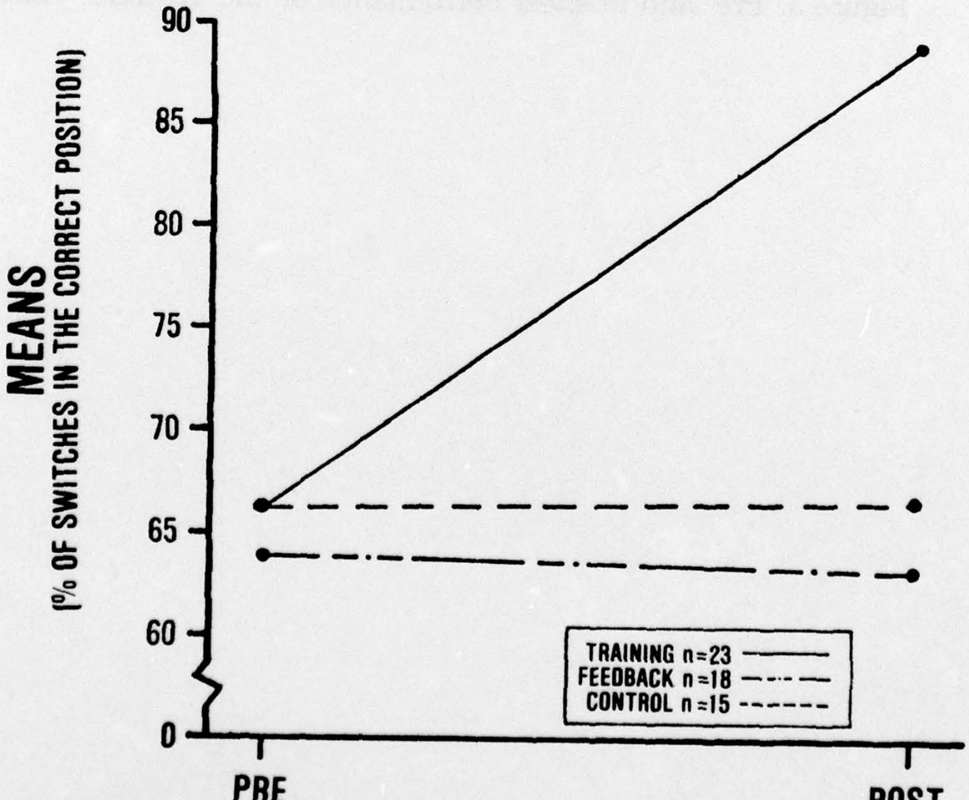

Figure 2. Pre- and Posttest Performance on the Contact Investigation Task.

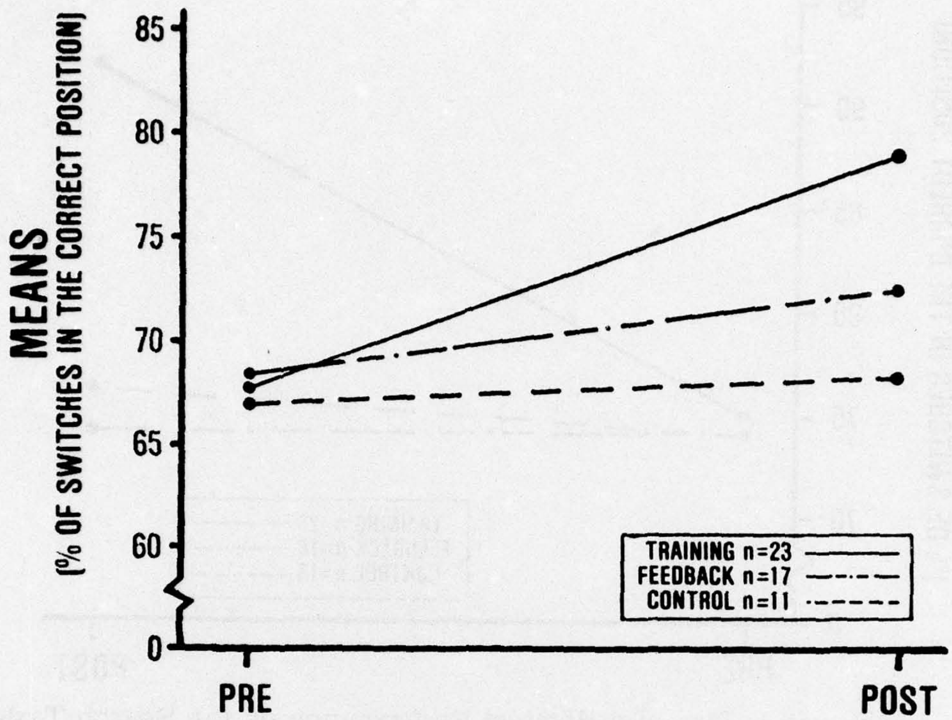

Figure 3. Pre- and Posttest Performance on the Tracking Task.

Results on Auxiliary Uses

For auxiliary uses of the AN/BQR-20A, the task areas of ping interception and SNR calculation were selected for testing. As shown in Figure 4, on the ping interception task no group showed significant improvement between pre- and posttesting, although the trend of the Training Group was in the expected direction. In view of the relatively high performance levels on the pretest, failure to reach significance levels of improvement can probably be attributed to a ceiling effect. As shown, the average pretest performance level for the three groups was about 87 percent.

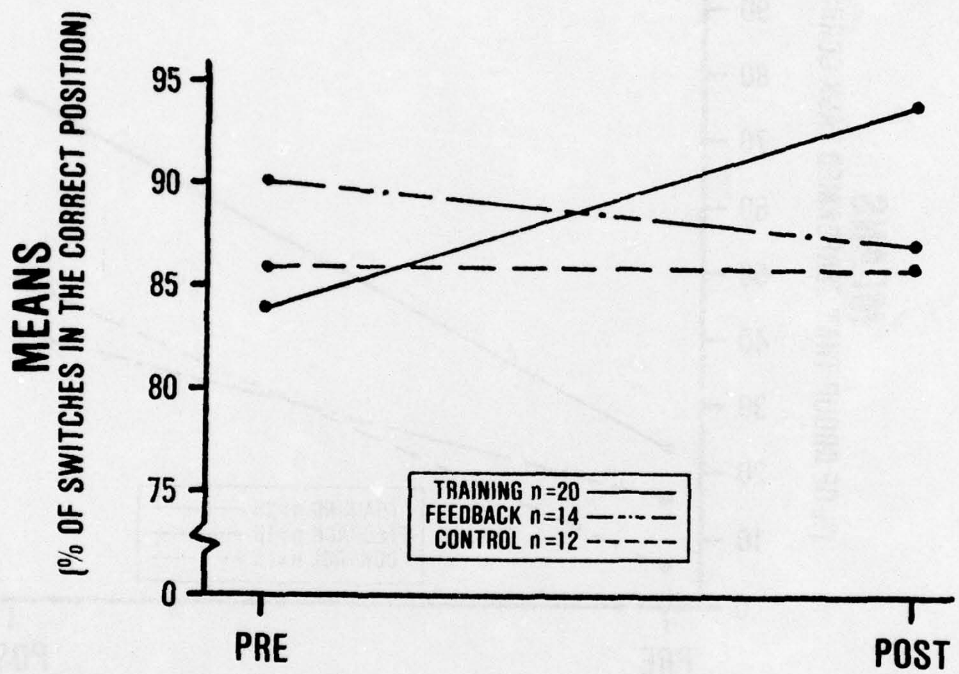

Figure 4. Pre- and Posttest Performance on the Ping Interception Task.

On the SNR determination task, the improvement between pre- and posttesting was better for all groups than for any other task. On the posttest, all three groups showed significant improvement over pretest performance, but the groups did not differ statistically from each other. It should be pointed out, however, that pretest performance levels were quite low, as shown in Figure 5. Results on the SNR task are an exception to the general finding. On all of the other tasks, the Control and Feedback Groups showed little or no improvement between pre- and posttesting. This discrepant finding can probably be accounted for by the nature of the SNR task. Since SNR can be calculated

at a variety of front panel control settings, learning to do this task is quite simple, even though many STs could not do this task on the pretest. It generally involves merely setting the mode selector switch to the proper position and determining the approximate dB value from the CRT presentation. In view of the simplicity of this task, it seems likely that learning occurred from exposure to the pretest and this contributed to the improvement shown by all groups.

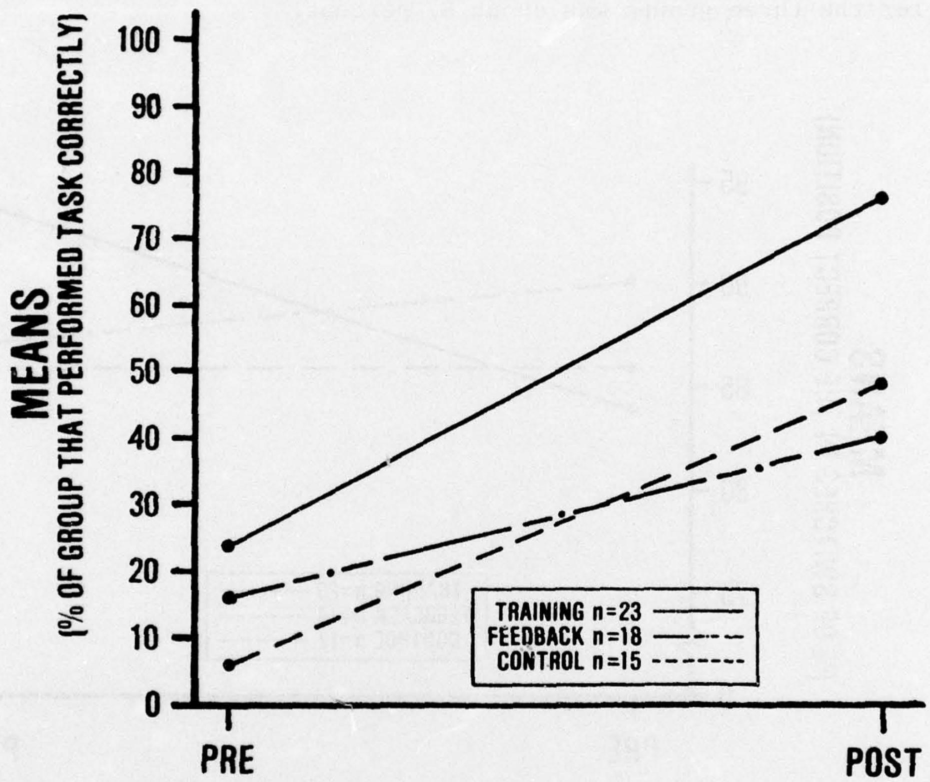

Figure 5. Pre- and Posttest Performance on the Signal-to-Noise Ratio Task.

Written Test

There were two categories of questions included in the written test. The first category contained 31 questions relating specifically to the operation of the AN/BQR-20A. In general, these questions covered aspects of operation which were not included in the performance test. The second category, consisting of 11 questions, pertained to general sonar knowledges which an operator should know to properly utilize this equipment. When the written test was constructed, it was anticipated that training materials would be developed to cover these supporting knowledges; however, due to time and personnel constraints it was not possible to develop such training materials before testing began. Therefore, the two categories of questions were separately analyzed

because the training materials provided instruction on the former category of questions but not on the latter. On the equipment-related questions, pretest performance by all groups was quite similar, as shown in Figure 6. On the posttest, however, the Training Group improved significantly (13%) while the Feedback and Control Groups showed only slight improvement. On questions concerned with general sonar knowledge, there was no significant difference between groups on pre- and posttesting, although all groups did show slight improvement on the posttest. Since the training materials covered operation of the AN/BQR-20A but not general sonar knowledges, it was expected that the Training Group would show improvement on the equipment-related questions but would not improve appreciably on general sonar knowledges.

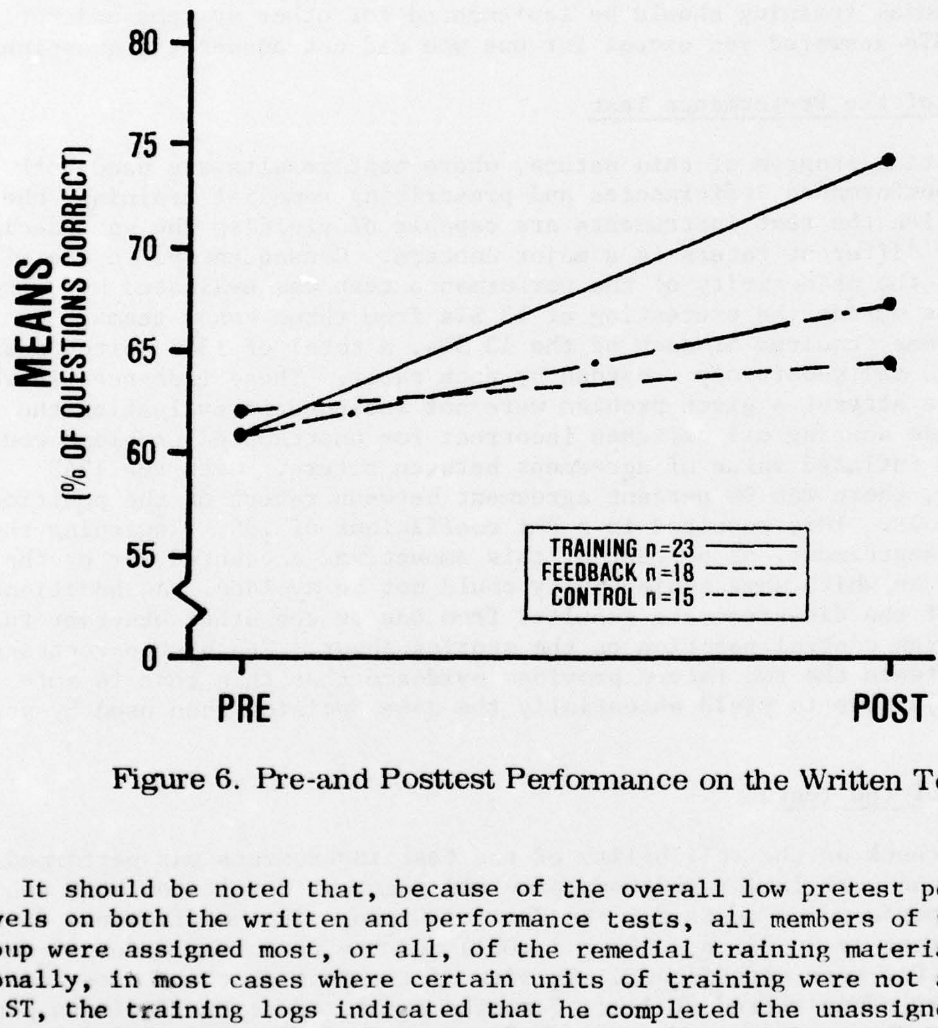

Figure 6. Pre-and Posttest Performance on the Written Test.

It should be noted that, because of the overall low pretest performance levels on both the written and performance tests, all members of the Training Group were assigned most, or all, of the remedial training materials. Additionally, in most cases where certain units of training were not assigned to an ST, the training logs indicated that he completed the unassigned units on his own initiative. Thus, because of the overall need for training in the case of this equipment, the value of diagnostic feedback was not as evident as it might be in other applications of such a program. Ideally, diagnostic feedback should provide for substantial savings in training time and effort to the individual by pointing out those specific areas in which he should concentrate his training efforts.

During posttesting, members of the Training Group were asked to complete a brief questionnaire in which they evaluated the value of the diagnostic feedback information and the training materials. On a 10-point scale, with 0 being essentially useless and 10 being very helpful, the value of the feedback information on specific deficiencies received an overall rating of 7.4. On the same 10-point scales, the self-instruction lessons received an average rating of 7.5, the logic trees 6.9, and the drills and associated tapes 6.0 in terms of how helpful these materials were in fulfilling personal needs for training. In response to the question, "Do you feel that the use of these training materials helped you to better understand the system and to operate it more effectively?," all of the STs answered yes with the exception of two respondents who did not answer the question. When asked whether a program which uses diagnostic tests to reveal deficiencies in performance and prescribes remedial training should be implemented for other systems and ratings, all of the STs answered yes except for one who did not answer the question.

Objectivity of the Performance Test

In a testing program of this nature, where test results are used both for diagnosing performance deficiencies and prescribing remedial training, the degree to which the test instruments are capable of yielding the same decisions when used by different raters is a major concern. Consequently, in the ST application, the objectivity of the performance test was evaluated by using two observers during the pretesting of 13 STs from three sonar teams. In the 12 problems required of each of the 13 STs, a total of 1348 switch positions were observed and separately recorded by each rater. Those instances in which an ST did not attempt a given problem were not included in evaluating the results, since scoring all switches incorrect for unattempted problems would result in an inflated value of agreement between raters. Over the 1348 observations, there was 96 percent agreement between raters on the position of the controls. This resulted in a Phi coefficient of .90. Regarding the 4 percent disagreement, 62 percent of this amount was accounted for by the CRT controls on which some subjectivity could not be avoided. An additional 12 percent of the disagreements resulted from one or the other observer failing to mark a given control position on the scoring sheet. The high percentage of agreement between the two raters provides evidence that this test is sufficiently objective to yield essentially the same decision when used by various raters.

Reliability of the Tests

A rough check on the reliability of the test instruments was performed by calculating the correlations between pre- and posttest results on both the written and performance tests for the Control Group. The coefficients for both the written test (r = .88, n = 16; p < .001) and the performance test (r = .61, n = 16, p < .01) were significant. In view of the fact that the pre- and posttests were administered at least 5 months apart, these coefficients provide evidence that the tests have a considerable degree of stability over time.

CONCLUSIONS

The results from the 12 ST teams tested indicate that, in the FBM fleet, there are serious overall deficiencies in the operation of the AN/BQR-20A. The training packages which were developed appear to be capable of correcting these deficiencies. It should be remembered that the considerable improvement shown by the Training Group was the result of an average of less than 11 hours of training during one patrol. It is likely that more extensive use of the materials will result in additional improvement.

In this application of the Personnel Readiness Training program, feedback in the form of specific performance deficiencies was not in itself sufficient to bring about improvement in job performance. This could be due to a lack of AN/BQR-20A training materials in the Fleet. During the course of this project, it was found that existing documentation, while technically accurate, is inadequate and poorly organized from the training standpoint. Apparently, members of the Feedback Group believed the diagnostic information they were given was helpful; on the posttest debriefing questionnaire, STs in the Feedback Group rated the value of the diagnostic feedback at 7.4 on a 10-point scale with 10 being very helpful. Nevertheless, this group showed little or no improvement on most tasks. It could be that, even though feedback information was considered beneficial, the STs found it difficult or impossible to overcome their deficiencies through existing documentation. If appropriate training materials had been available, their performance might have shown greater improvement on the posttest.

RECOMMENDATIONS

Because operator deficiencies seem to be very widespread in the FBM fleet, it appears that the diagnostic testing/shipboard training program should be implemented in two phases, starting with a shipboard training phase and then incorporating a diagnostic testing phase. Since the diagnostic testing resulted in all of the STs being assigned most, or all, of the training materials, initiation of AN/BQR-20A diagnostic testing in the FBM fleet at this time would appear to be an inefficient solution to the problem. Therefore, because of existing low performance levels, it would appear to be more efficient to carry out implementation in two phases. In the initial phase, one set of the shipboard remedial training materials would be distributed to the Sonar Division of each crew on all FBM submarines. This would provide adequate training documentation which presently does not exist on this equipment. In the second phase of implementation, which should occur approximately 6 months after distribution of the training materials, diagnostic testing would be initiated to determine fleet performance levels after exposure to the training materials. Refresher training from the shipboard training package would be prescribed on the basis of test results. If, after testing a sample of FBM ST teams, it is found that performance levels have improved to an adequate level, the diagnostic testing could be terminated. If, on the other hand, performance levels of a significant number of STs are still found to be inadequate, the diagnostic testing and assignment of remedial training should be continued. The testing could be incorporated into an ongoing program such as Operational Readiness Inspections.

For the initial phase, two sets of training materials consisting of self-instructional units, logic trees, drills, and training tapes would be required for each submarine. The estimated cost of reproducing the two sets of materials would be $30.00 per submarine. For the second phase, the diagnostic testing program would require a highly qualified AN/BQR-20A operator to administer the test. He should be an ST of E-7 pay grade or higher. One AN/BQR-20A would be required to conduct the performance test. Since this equipment is presently installed at most submarine shore facilities, arrangements for time-sharing could probably be arranged at the Fleet Training Centers or Sonar Information Centers. If a dedicated AN/BQR-20A is required, however, the approximate cost of a new system is $22,500. The only additional requirement would be a classroom for testing purposes.

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